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CASE STUDY: IMPACT OF MEAN MONTHLY DIURNAL TEMPERATURE VARIATION AND RAINFALL EVENTS ON THE OCCURRENCE OF MALARIA CASES AND PREPARATION OF DISEASE TRANSMISSION WINDOW IN KOLHAPUR DISTRICT

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ABSTRACT

The goal of this study was to prepare suitable disease transmission window for malaria with assessing the weather's impact on monthly occurrence of malaria cases in Kolhapur district. The interaction between climatic factors and their biological influence on mosquito and parasite life cycle is a key factor in the association between weather and malaria. In the present study, impact of mean monthly diurnal temperature variations on the incidence of malaria cases found maximum during monsoon (June to September) followed by post-monsoon (October November and December). In the month of June, November, January and May incidence of malaria cases were found maximum in monsoon, post monsoon, winter and pre monsoon season respectively. The mean monthly diurnal temperature variation based disease transmission window during monsoon and the pre monsoon season was ranged between 4.0 and 10.2 0C & 10.2 and 17.7 0C were found favourable for incubation and transmission of mosquitos which results in more incidence of malaria cases. Rainfall events and plays an important role in malaria epidemiology. The rainfall event transmission window was based on rainfall event counts found between 2 and 9 rainfall events in the pre monsoon while 3 and 12 on the post monsoon season which found significantly during this study. These findings would be helpful for local authorities in the monitoring malaria cases at micro level.

KEYWORDS: Malaria, Public Health & Climate Factors

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INTRODUCTION

Indian public health care is divided between the state and national government systems in terms of making decisions, as the national government addresses broadly applicable healthcare issues such as overall family welfare and prevention of major diseases, while the state governments handle aspects such as local hospitals, public health, promotion and sanitation, which differ from state to state based on the particular communities involved [5]. Interaction between the state and national governments does occur for healthcare issues that require larger scale resources or present a concern to the country as whole.

Health is influenced by the external environment, it is only recently that the relationship between health and climate has become a focus of community and public health services. Advances in understanding of weather and climate sciences on the one hand and human health on the other are providing new opportunities for early detection, prediction and prevention of the adverse health effects of hazards as diverse as tropical cyclones, floods,

Case Study

heat waves and cold spells, air quality, wildfires, droughts and disease epidemics. Early warning of disease outbreaks and a timely response makes prevention possible [19].

Climate is a key variable in managing the overall burden of disease, particularly in developing countries where the ability to control climate-sensitive diseases constrains the prospects of achieving the United Nations Millennium Development Goals. The health sector can also use climate information effectively in epidemic early warning systems. Seasonal forecasts of temperature and rainfall, which are useful indicators of the likely occurrence of malaria outbreaks, can be used to implement a program of heightened epidemic surveillance, while real-time temperature and rainfall estimates can be used to initiate selective interventions and to support the early detection of disease outbreaks. Climate change is high on the agenda of public health services worldwide [9].

Malaria is a major vector-borne disease in India. Based on vast geographic areas with associated topographic and climatic diversity, the variable Malaria epidemiology in India is associated with high parasite genetic diversity and rapidly evolving drug resistance, differential distribution of vector species and emerging insecticide resistance and underlying human genetic diversity and past evolutionary histories [21]. The impact of a bed net program for Malaria control depends on knowing the climate trend during the assessment period. In the absence of any intervention, increasingly wet years may well increase the mosquito population, resulting in a higher incidence of Malaria, while conversely, periods of drought may well decrease the mosquito population and reduce the incidence of malaria. It is also possible that the trend could reverse in certain locations; dry spells favouring transmission when normally running streams leave intermittent pockets of water during drought periods which then become suitable for mosquito breeding. Thus, it is important to understand the environmental context to develop an accurate picture of the efficacy of any intervention strategy.

Further, changing climatic patterns has possibly changed the Malaria epidemiology to a great extent. The outcome of these changes is an increased incidence of Plasmodium falciparum over the P. vivax Malaria in recent years. The above facts and associated rapid shifting trend of Malaria epidemiology makes India a hot-spot for malaria research and from the health sector's perspective, climate information needs to be geographically specific and readily available on the time-scales relevant to public health decision-makers.

MATERIALS AND METHODS

Materials

This study examines reported malaria cases in Kolhapur district of Maharashtra state linked with climate data obtained from the National Climate Data Center (NDC) Pune. The reported Malaria cases for 7 year period (2003-2009) were obtained from District Health Office Kolhapur.

Diurnal Temperature Variation

The diurnal temperature variation is an important indicator for occurrence of malaria. The daily diurnal temperature variation is calculated from the data set. Further the mean monthly diurnal temperature variation vaules were calculated and correlated with monthly maleria cases.

Monthly Rainfall Events

The amount of rainfall received over an area is an important factor in assessing the amount of water for occurrence of malaria cases. The daily rainfall data series of Kolhapur station were assembled and monthly rainfall events

were calculated for the present study. The term "rainfall event" is used to denote the occurrence of rain amount 0.1 mm or more rainfall.

Data Analysis

To examine the relationship between the monthly incidence of malaria and monthly mean diurnal temperature variation and monthly rainfall events, the monthly calculation was done by applying Pearson's correlation analysis. The Bar and Contour graphs were plotted using Chart block and Surfer 8 software respectively.

RESULTS AND DISCUSSIONS

RESULT

Monthly Incidance of Maleria Cases

There was consistency in the incidence of malaria cases in the all the months from 2003 to 2009. In case of monthly variations in the incidence of malaria cases the peak seasons were monsoon (June to September) and post-monsoon (October November, December)

(Table 1). Although incidence occurred in pre monsoon is also contributed significantly but in winter season less incidence of malaria cases was observed. In the month of June, November, January and May incidence of Malaria cases were found maximum in monsoon, post monsoon, winter and pre monsoon season respectively

Monthly Diurnal Temperature Variation

The mean monthly diurnal temperature variation during monsoon season was found less compared to rest of the seasons. The highest mean monthly diurnal temperature variation was observed in the month of January 2008 (18.3 ^{0}C) whereas lowest was found in the month of July 2009 (4.0 ^{0}C). The winter season show highest mean monthly diurnal temperature variation followed by Pre monsoon season. In the winter season the mean monthly diurnal temperature variation range was between 14.1 and 18.3 ^{0}C whereas in pre monsoon season was between 10.2 and 17.7 ^{0}C. During monsoon season the mean monthly diurnal temperature variation range was between 4.0 and 10.2 ^{0}C whereas in the post monsoon season was between 9.1 and 17.2 ^{0}C.

Monthly Rainfall Events

The monthly rainfall events were found significantly in all months except January. The February, March and December month show negligible rainfall events during the study period. During monsoon season consistent rainfall events were found followed by Pre monsoon season. There was no significant trend was found in rainfall events in all seasons, but in monsoon season, July and August months rainfall events were comparatively greater than June and September month.

DISCUSSIONS

Impact of Climatic Variables on Occurance of Maleria Cases

Monthly Temperature Variation

The impact of weather parameters on the incidence of malaria cases has been studied [6, 7, 9, 22, 23] and in case of temperature, many researchers were motivated and conducted studies [1, 4, 14, 15, 20]. The transmission of malaria is determined by climatic, non-climatic and biological factors. The climatic variables exhibit impact on the incubation rate of Plasmodium parasites and the breeding of Anopheles and thus considered as the important environmental contributors to

malaria transmission [18]. The table 4 indicate monthly correlation analysis between mean monthly dirunal temperature variation and monthly maleria incidance cases. In the present study postive correaltion was found in all the months except December, January and February. Though mean monthly diurnal temperature variation was comapritively greater in the December, January and February months but the actual temperature ranges are not favourable for breeding of mosquites results in less number of maleria cases registered in these months. Also, there was no such strong negative correlation found during this study. During the Monsoon season, Auguest month was showing the highest correlation value followed by September month. Throughout the season there were good correlation values observed, indicating the variation in mean monthly diurnal temperature variation has positive relations with incidence of malaria cases. In post monsoon season, though there was high monthly positive correlation valus asssociated with maleria cases but found statistically insignificant. In pre monsoon season, the April month was showing the highest correlation and found strong month vis month strong correlation. In winter season there is no any strong correlation found between these parameters. In monsoon season, during August and September months, mean monthly diurnal temperature variation between 5 to 10 ^{0}C and during June and July months 4 to 10 ^{0}C was found more favourable for maleria mosqiuto trasmision. In general, during monsoon season 4 to 10 ^{0}C mean monthly diurnal temperature variation was found significantly in temperature transmission window for occurrence of malaria cases in Kolhapur district. In pre monsoon season, during the month of April, mean monthly diurnal temperature variation between 14.0 to 17.5 ^{0}C and during March month 14.3 to 17.7 ^{0}C was found more favourable for malaria mosquito transmission. Therefore, in general during pre monsoon season 14 to 18 ^{0}C mean monthly diurnal temperature variation was found significantly for temperature transmission window for occurrence of malaria cases in Kolhapur district. Therefore, in Kolhapur district, during monsoon and pre monsoon season the mean monthly diurnal temperature variation range between 4.0 and 10.2 ^{0}C & 10.2 and 17.7 ^{0}C was found favourable for incubation and transmission of mosquitos which results in more incidents of malaria cases.

Monthly Rainfall Events

The rainfall is the main parameter in weather variability and associated malaria cases with many studies showing the importance of rainfall as a precipitating factor for malaria transmission [3, 8, 11, 12,13, 15, 17, 18]. For rainfall to have a positive effect on malaria cases, the monthly temperature variation must be enough to support mosquito and parasite development [2], and, as in this present study, the effect of rainfall on cases becomes more immediate with less monthly temperature variation during the monsoon season. Rainfall plays an important role in the Malaria epidemiology because water not only provides the medium for the aquatic stages of the mosquito’s life, but also increases the relative humidity and thereby the longevity of the adult mosquitoes. The impact of rainfall on the transmission of malaria is very complicated, varying with the circumstances of a particular geographic region and depending on the local habits of mosquitoes. Rains may prove beneficial to mosquito breeding if it is moderate, but may destroy breeding sites and flush out the mosquito larvae when it is excessive [16]. In the present study, correlation analysis was studied between monthly rainfall events and monthly malaria cases represented in table 5. During the study positive correlation as found in all the months except in the months of November, December and February also rainfall events in these months were found negligible compared to rest of the months. During monsoon season positive correlation has been found significantly. The early rains during the onset of monsoon was found suitable for incubation and transmission of malaria disease. After the frequent rain spells during the July and August months, the water bodies acts as new breeding sites and helps further developmental stages results in more incidence of malaria cases during this season. During the pre monsoon season, the role of irregular rainfall events and localised rainfall was found beneficial for egg hatching and mosquito breeding results

increase in malaria cases. The rainfall events ranged between 2 and 9 was found significant for the malaria transmission. During the post monsoon season, prolonged rainfall events further renew the water bodies results in favourable condition for mosquito breeding. The rainfall events ranged between 3 to 12 was found significant for transmission of malaria. Therefore, for Kolhapur district, during pre monsoon and the post monsoon season, the rainfall event transmission window was found between 2 and 9 numbers & 3 and 12 numbers respectively.

Malaria Disease Transmission Window Using Monthly Mean Diurnal Temperature Variation and Monthly Rainfall Events for Kolhapur District

Weather factors alone explain seasonal cycles but were not accurate in explaining the magnitude of unusually bad years. In the present study, a weather based disease transmission Window for malaria in Kolhapur district was created for the different seasons, which based on monthly mean diurnal temperature variation and monthly rainfall events. This disease transmission window will play a key role and need to be considered in policy decisions in the monitoring and control the spread of malaria at micro level.

CONCLUSIONS

The climatic variables exhibit impact on the incubation rate of Plasmodium parasites and the breeding of Anopheles and thus considered as the important environmental contributors to malaria transmission. In case of monthly variations in the incidence of malaria cases, the peak seasons was monsoon (June to September) followed by post-monsoon (October, November and December). In the month of June, November, January and May incidence of malaria cases were found maximum in monsoon, post monsoon, winter and pre monsoon season respectively. During monsoon season the mean monthly diurnal temperature variation range was between 4.0 and 10.2 ^{0}C whereas in the post monsoon season was between 9.1 and 17.2 ^{0}C. Therefore, in Kolhapur district, during monsoon and pre monsoon season the mean monthly diurnal temperature variation range between 4.0 and 10.2 ^{0}C & 10.2 and 17.7 ^{0}C was found favourable for incubation and transmission of mosquitos which results in more incidents of malaria cases. Rainfall plays an important role in malaria epidemiology. During monsoon season, rainfall events occurred in July and August months were comparatively greater than June and September months. During the pre monsoon season, the rainfall events ranged between 2 and 9 was found significant for the malaria transmission in which the role of irregular rainfall events and localised rainfall was found responsible for egg hatching and mosquito breeding results increase in malaria cases. During the post monsoon season, prolonged rainfall events further renew the water bodies results in favourable condition for mosquito breeding. The rainfall events ranged between 3 and 12 was found significant for the malaria transmission. Therefore, for Kolhapur district, in pre monsoon and the post monsoon season, the rainfall event transmission window was found between 2 and 9 & 3 and 12 rainfall events respectively.

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FIGURE AND TABLE LEGENDS

Figures

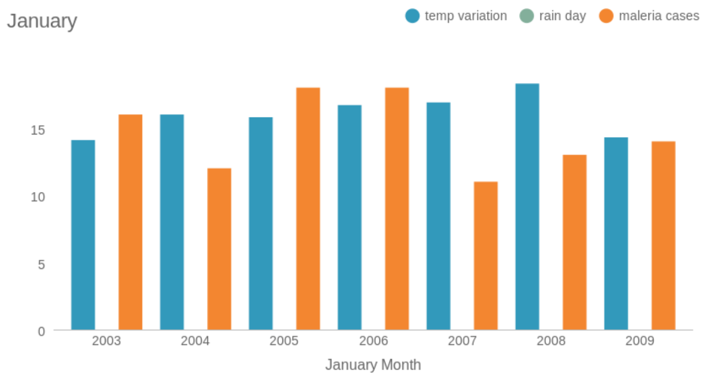

Figure 1: Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases in January

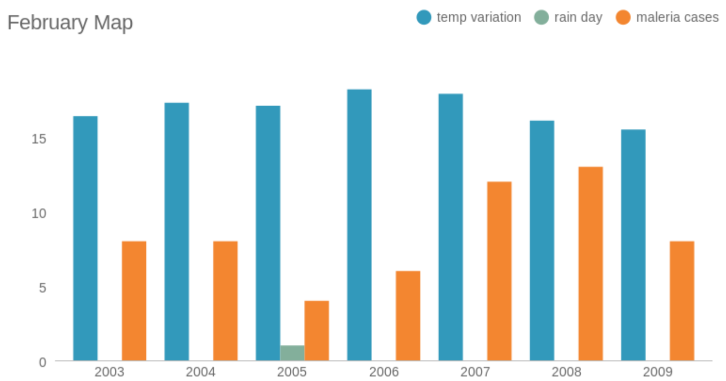

Figure 2: Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases in February

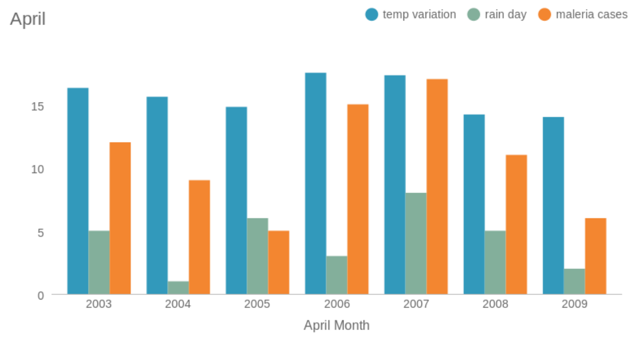

Figure 3: Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases in April

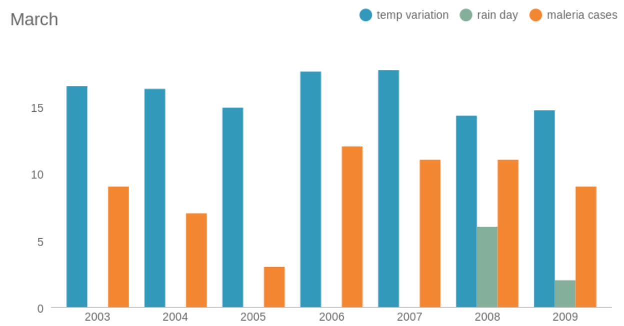

Figure 4: Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases in March

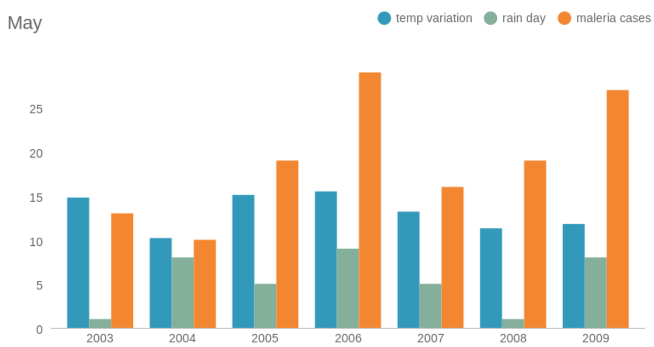

Figure 5: Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases in May

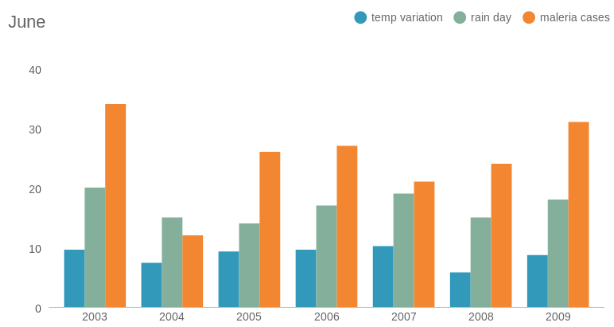

Figure 6: Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases in June

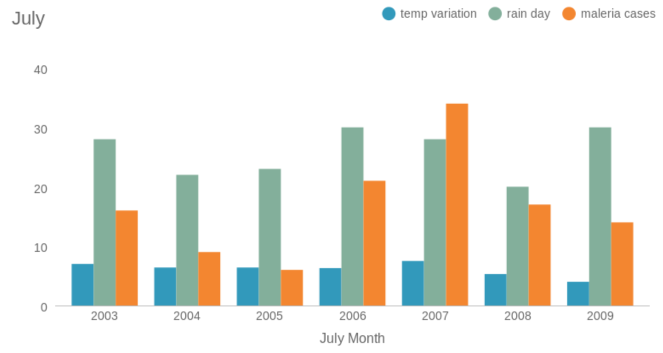

Figure 7: Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases in July

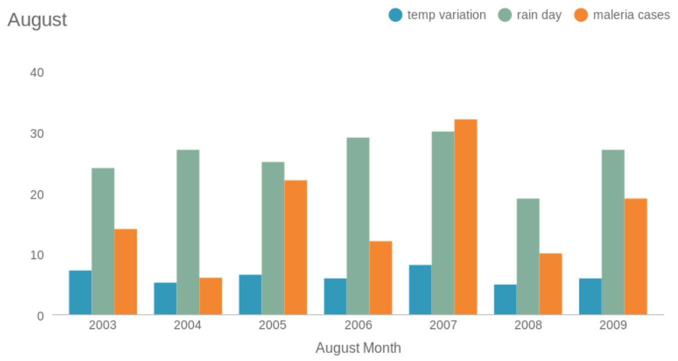

Figure 8: Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases in August

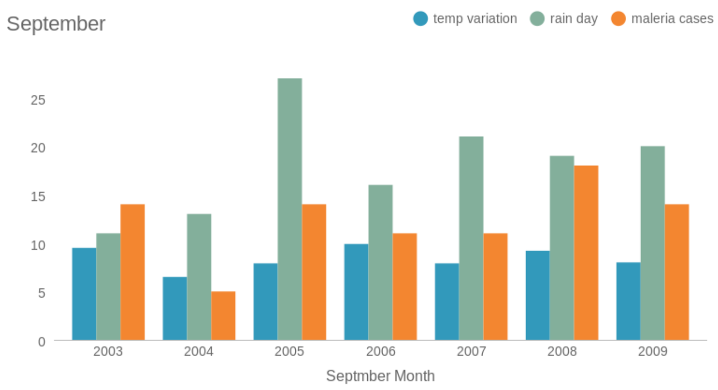

Figure 9: Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases in September

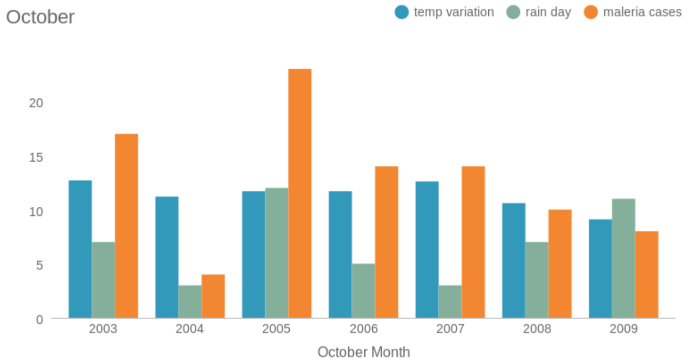

Figure 10: Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases in October

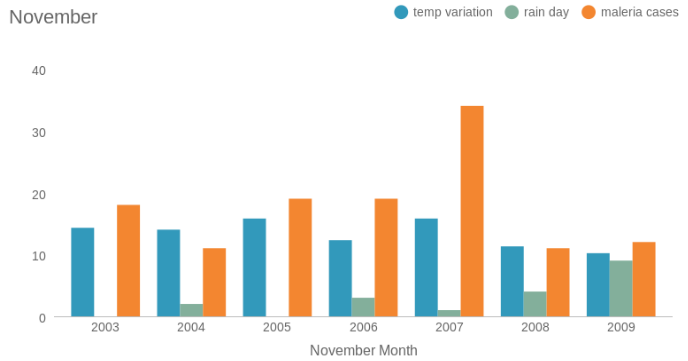

Figure 11: Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases in November

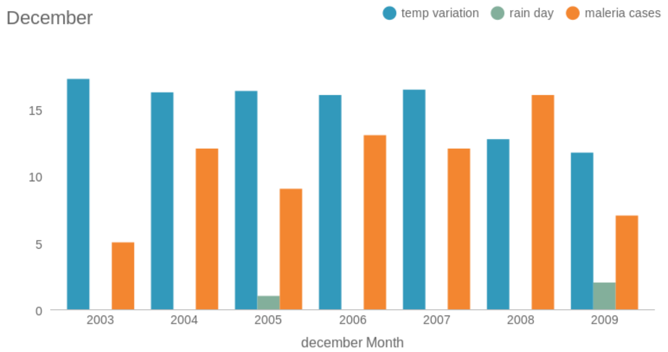

Figure 12: Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases in December

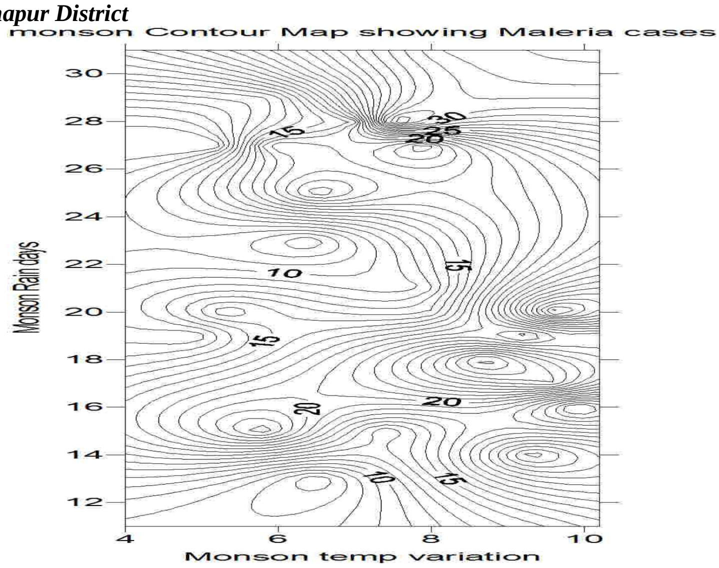

Figure 13: Monsoon Season Contour Map Showing Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases

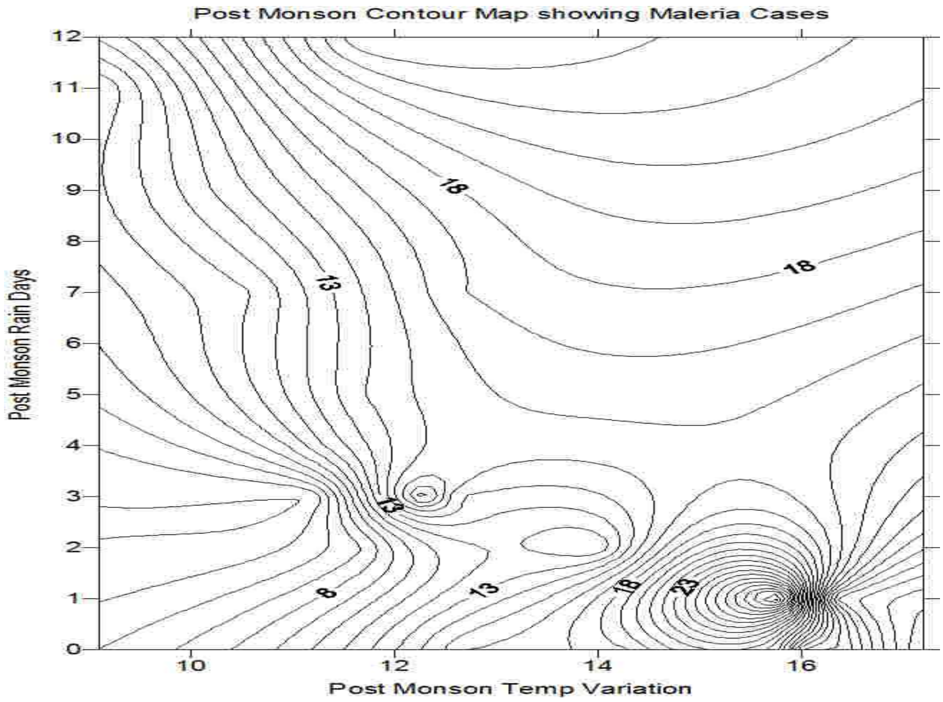

Figure 14: Post Monsoon Season Contour Map Showing Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases

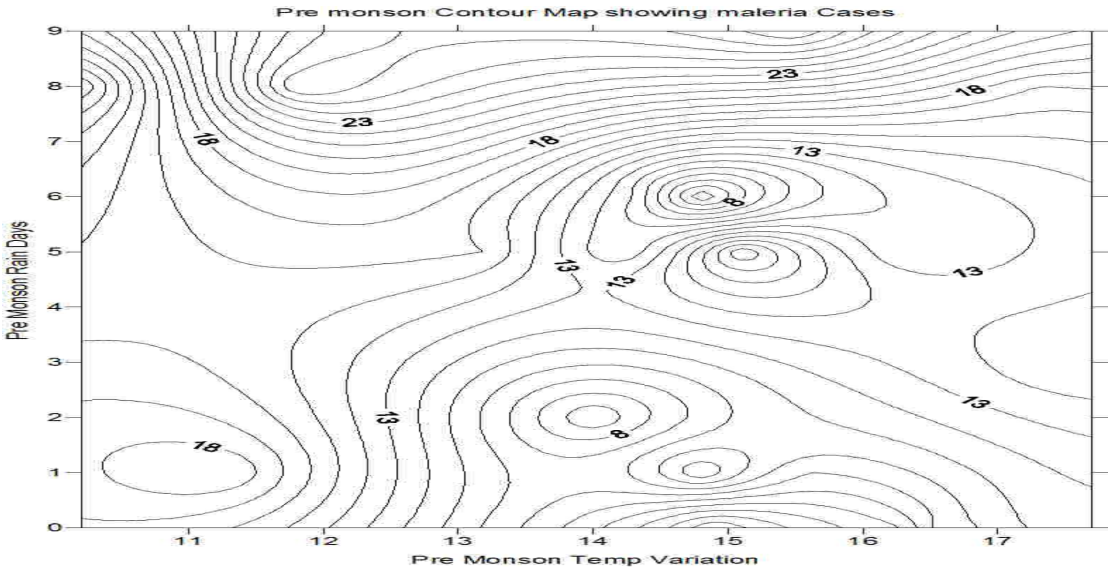

Figure 15: Pre Monsoon Season Contour Map Showing Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases

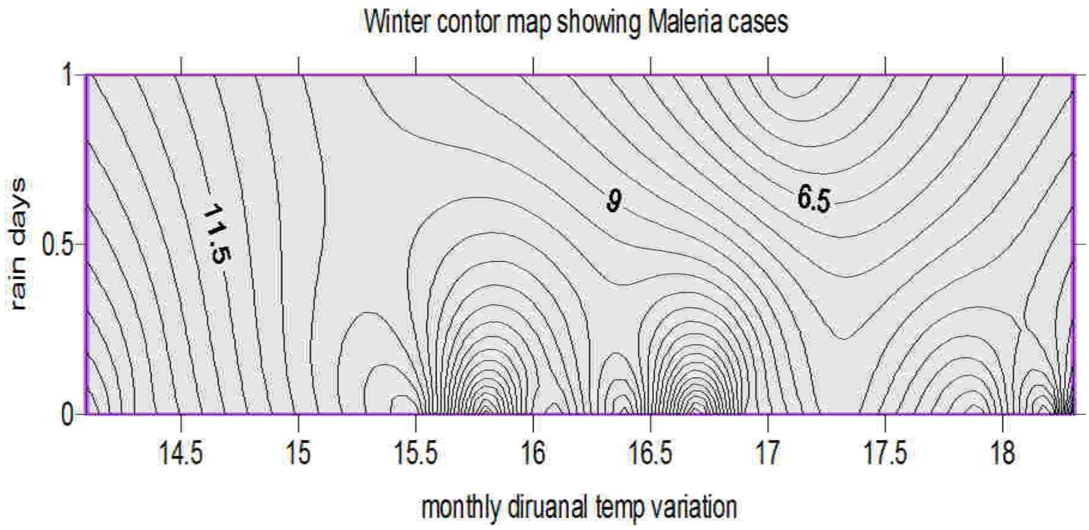

Figure 16: Winter Season Contour Map Showing Mean Monthly Diurnal Temperature Variation, Rain Events and Malaria Cases

Tables

Table 1: Monthly and Seasonal Incidence of Malaria Cases

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2003	16	8	9	12	13	34	16	14	14	17	18	5
2004	12	8	7	9	10	12	9	6	5	4	11	12
2005	18	4	3	5	19	26	6	22	14	23	19	9
2006	18	6	12	15	29	27	21	12	11	14	19	13
2007	11	12	11	17	16	21	34	32	11	14	34	12
2008	13	13	11	11	19	24	17	10	18	10	11	16
2009	14	8	9	6	27	31	14	19	14	8	12	7
Total	**102**	**59**	**62**	**75**	**133**	**175**	**117**	**115**	**87**	**90**	**124**	**74**

Table 2

Season	Monsoon	Post Monsoon	Pre Monsoon	Winter
Total	494	288	270	161

Table 3: Monthly Diurnal Temperature Variation

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2003	14.1	16.4	16.5	16.3	14.8	9.6	7	7.2	9.5	12.7	14.3	17.2
2004	16	17.3	16.3	15.6	10.2	7.4	6.4	5.2	6.5	11.2	14	16.2
2005	15.8	17.1	14.9	14.8	15.1	9.3	6.4	6.5	7.9	11.7	15.8	16.3
2006	16.7	18.2	17.6	17.5	15.5	9.6	6.3	5.9	9.9	11.7	12.3	16
2007	16.9	17.9	17.7	17.3	13.2	10.2	7.5	8.1	7.9	12.6	15.8	16.4
2008	18.3	16.1	14.3	14.2	11.3	5.8	5.3	4.9	9.2	10.6	11.3	12.7
2009	14.3	15.5	14.7	14	11.8	8.7	4.0	5.9	8.0	9.1	10.2	11.7

Table 4: Monthly Rainfall Events Recorded at Kolhapur District

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2003	0	0	0	5	1	20	28	24	11	7	0	0
2004	0	0	0	1	8	15	22	27	13	3	2	0
2005	0	1	0	6	5	14	23	25	27	12	0	1
2006	0	0	0	3	9	17	27	26	16	5	3	0
2007	0	0	0	8	5	19	28	27	21	3	1	0
2008	0	0	6	5	1	15	20	19	19	7	4	0
2009	0	0	2	2	8	18	28	27	20	11	9	2

Table 5: Correlation Analysis Table between Mean Monthly Diurnal Temperature Variation and Malaria

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monthly Correlation	-0.27	-0.19	0.42	0.83	0.34	0.37	0.38	0.82	0.61	0.55	0.66	-0.18
T test	0.25	0.00	0.00	0.02	0.05	0.00	0.01	0.01	0.03	0.55	0.20	0.01

Table 6: Correlation Analysis Table between Monthly Rainfall Events and Malaria

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monthly Correlation	---	-0.62	0.31	0.40	0.44	0.51	0.45	0.45	0.37	0.45	-0.47	-0.49
T test	0.00	0.00	0.00	0.01	0.00	0.01	0.03	0.02	0.04	0.05	0.00	0.00

Table 7: Malaria Disease Transmission Window

Sn	Parameters	Monsoon	Pre Monsoon
1	Monthly mean diurnal tempe rature variation	4 - 10 ^{0}C	14 - 18 ^{0}C

Table 8

Sn	Parameter	Monsoon	Pre Monsoon	Post Monsoon
2	Monthly Rainfall Events	11-30	2 - 9	3 -12